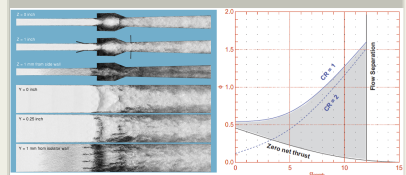
Machine-Learning & QMU for Multi-Fidelity Analysis of Scramjet Operability, Phase I

Completed Technology Project (2017 - 2017)

Project Introduction

Dual-mode scramjets have the potential to operate efficiently in a variety of flight conditions without requiring complicated variable configurations, thus providing cost-effective access to space and potential for high-speed atmospheric transport. However, the successful design and operation of these systems requires the identification of potential failure modes related to the transition between ramjet and scramjet modes and inlet-isolator-combustor unstart events. High-fidelity computer simulations and detailed diagnostics in a ground-based facility provide invaluable data, but cannot be routinely used for an extensive exploration of design solutions due to cost. Furthermore, it is challenging to formulate efficient design strategies that accommodate performance constraints and guarantee safe operations; as a consequence safety factors (and limitations in vehicle operability) are typically introduced a-posteriori leading to suboptimal systems. Cascade's proposal aims at investigating modern scramjet systems using a combination of computational tools focusing on design strategies that a-priori include safety margins from unstart. The project goal is to combine machine-learning tools, in-house high-fidelity simulation capabilities, and high-throughput low fidelity engineering techniques within a risk-aware optimization framework that can potentially enhance the ability to generate safe and performant design. Machine learning will enable the extraction and categorization of knowledge from in-house high-fidelity data and experiments; the engineering tools afford the exploration of a large set of geometrical configurations and operating scenarios; the QMU (Quantification of Margins and Uncertainties) technique, will provide the optimization framework. Validation of the high-fidelity and low-fidelity tools with data from the HIFiRE experimental campaign will provide an explicit measure of the confidence in the simulations which will explicitly be included within QMU.



Left: Cascade's simulation of HIFiRE scramjet;
Right: operability region of a simplified scramjet model with the unstart bound estimated using QMU.

Machine-learning & QMU for multi-fidelity analysis of scramjet operability, Phase I Briefing Chart Image

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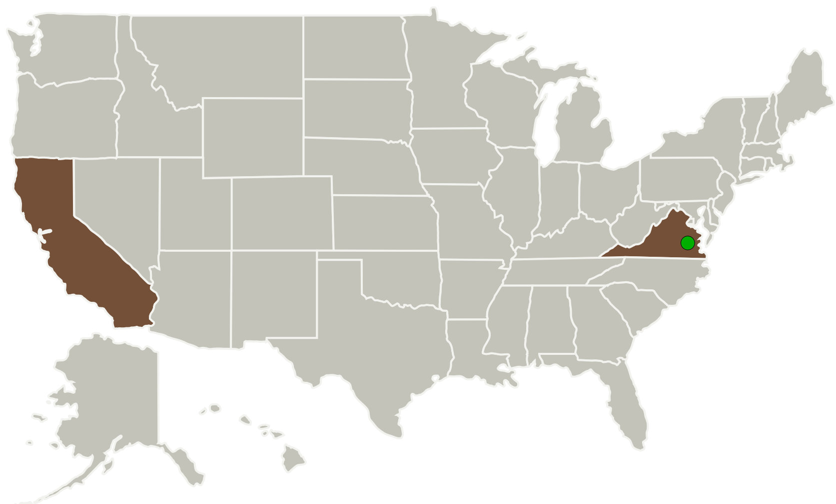
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
CASCADE Technologies, Inc.	Lead Organization	Industry	Palo Alto, California
Langley Research Center(LaRC)	Supporting Organization	NASA Center	Hampton, Virginia

Primary U.S. Work Locations	
California	Virginia

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

CASCADE Technologies, Inc.

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

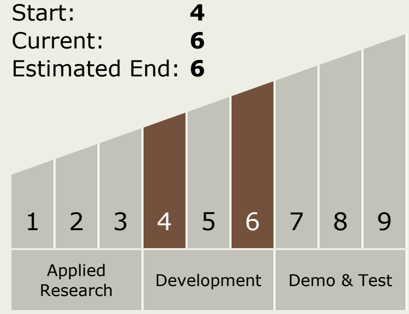
Carlos Torrez

Principal Investigator:

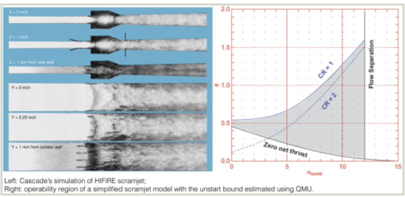
Amirreza Saghafian

Technology Maturity (TRL)

Start: **4**
Current: **6**
Estimated End: **6**



Images



Briefing Chart Image
Machine-learning & QMU for multi-fidelity analysis of scramjet operability, Phase I Briefing Chart Image
(https://techport.nasa.gov/image/135116)

Technology Areas

Primary:

- TX01 Propulsion Systems
  └─ TX01.3 Aero Propulsion
    └─ TX01.3.2 Turbine Based Combined Cycle

Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System